

SUPPRESSION OF SIMULATED ENGINE NACELLE FIRES

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The engine nacelle encases the jet engine compressor, combustor and turbine. A nacelle fire is typically a turbulent diffusion flame stabilized behind an obstruction in a moderately high speed air flow. The most likely source for a fire in the nacelle are leaks in the fuel lines carrying jet fuel or hydraulic fluid, that can feed the fire either as a spray or as a pre-vaporized gas. Temperatures as high as 150 °C are common in normal operating engine nacelles.

Extinguishment occurs when a critical amount of agent is transported to the flame, where it is entrained into the primary reaction zone. The extinction process is affected by a number of parameters, including the velocity of the air flow, the type and quantity of fuel, the system temperature, agent properties and concentration, and the flow field geometry (e.g., the location of obstacles in the flow field). Re-ignition is also dependent on these system parameters and should be considered independently from the extinction phenomena.

Halon 1301, or trifluorobromomethane (CF₃Br), has been used as the fire extinguishing agent for protecting aircraft engine nacelles because of its many positive attributes. However, its production will cease at the end of this year, leaving many aircraft needing an alternative. The Air Force will soon begin testing three candidate alternatives to halon 1301 in its full scale Engine Nacelle Test Facility. Because testing cannot be performed for all possible aircraft and conditions, knowledge is needed which will provide guidance in the extension of the full-scale data to untested systems and conditions.

Recently, the Air Force funded an experimental study which involved simulating an idealized engine nacelle fire¹⁻³. A coaxial turbulent spray burner was used, with jet fuel and hydraulic fluid as the fuels with the air at ambient and elevated temperatures. The research presented here extends that study to a broader range of suppression and re-ignition conditions, typical of in-flight engine nacelles.

The objective of the work is to document guidelines for fire suppression system performance based on improved understanding of the influence of various parameters on fire suppression in the engine nacelle. The primary objective of the proposed research is to produce organized guidance for adjusting the needed concentration of candidate fire suppressants over a range of engine nacelle fire conditions. This will be based on understanding the influence of various parameters on the flame extinction process in the engine nacelle.

Flame suppression measurements were conducted in a coaxial turbulent jet spray burner with JP8 fuel. The agents tested are CF₃I, HFC-125, and HFC-227. The mass and mass rate of application of agent required to achieve extinction of the spray flame is measured. A broad range of suppression and re-ignition conditions are tested and the influence of a number of flow parameters are investigated including the fuel and air flow, air and agent temperature, system pressure, rate of agent application, and agent injection interval.

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Results show that as the agent delivery interval decreases, the mass of agent required for suppression increases. Measurements also show that the air flow has little impact on the required mass (see Fig. 1 below).

References

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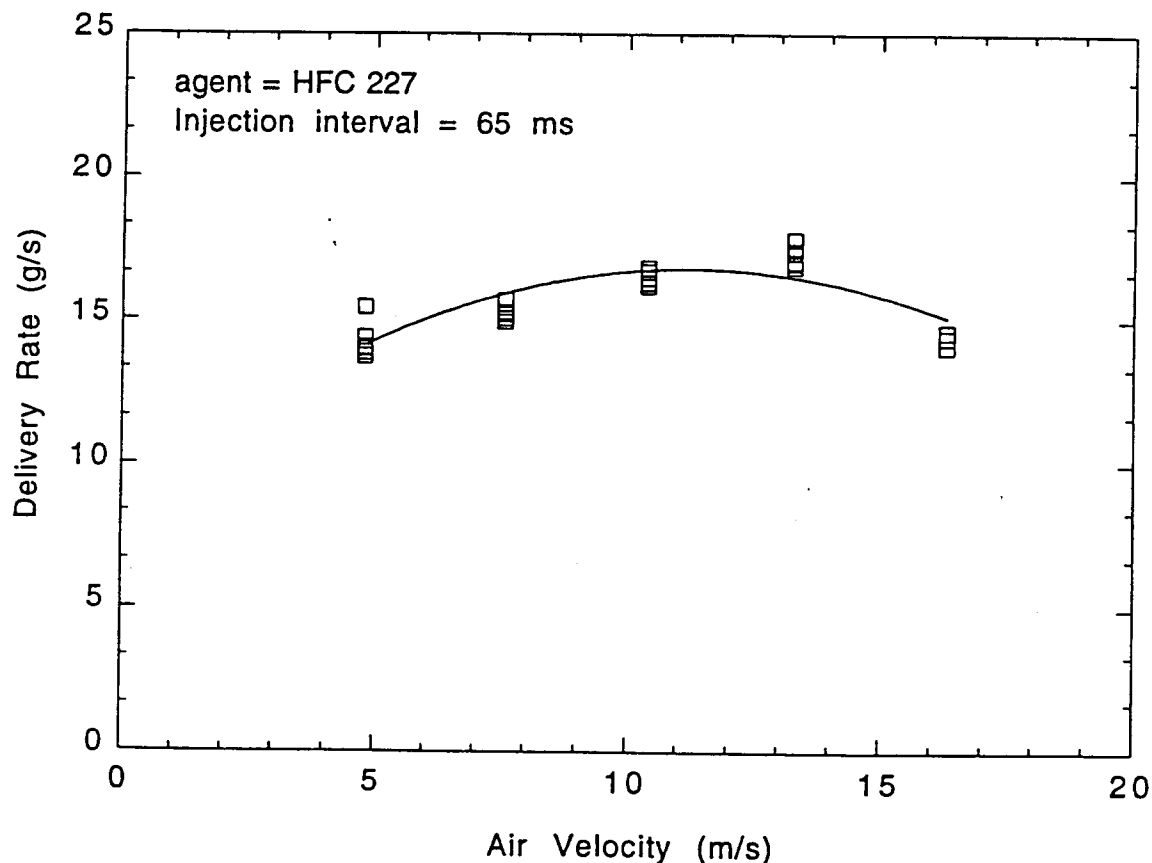


Figure 1 The mass delivery rate of agent required to extinguish the JP8 spray flame as a function of air velocity.